Intermountain Power Service Corporation
Over Fire Air System – IGS02-14
Controls Test Plan

Introduction
The following plan is designed to test the performance and operation of the new Over Fire Air (OFA) system installed on Unit #1 of the Intermountain Generating Station (IGS).

Objectives:
1) Validate operational capabilities of the OFA system
   a) Verify proper operation of OFA final control elements.
   b) Validate operation and accuracy of OFA instrumentation.
   c) Tune damper control through variable load ranges.
2) Validate performance capabilities of the OFA system.
   a) Verify emissions levels for NOx, CO, and unburned carbon at multiple loads, different fuel quality, and variable configurations of pulverizers in service.
   b) Verify air flows a multiple loads with variable configurations of pulverizers in service.
   c) Verify proper OFA system performance at high temperature and identify required cooling flows When OFA is out of service.
3) Restraints:
   a) Overfire Air flow will be limited to a maximum of 10% of total combustion air flow.

Testing Phases & Schedule
1) Phase 1 – Pre-operation testing: Mar. 27, 28, & 29
   Conducted off-line, prior to start-up, without air flow.
   a) Local Manual damper stroking test.
   b) Wiring validation.
   c) Motorized damper stroking test (manually initiated).
   d) Motorized damper stroking test (automatic mode with simulated inputs).

2) Phase 2 –OFA system operational testing: Apr. 1 & 2 - Conducted on-line, at temperature, and at different loads to verify proper OFA controls and mechanical operation.
   a) Test components:
      i) OFA port, inlet, and total air flow tests.
      ii) Measure port temperatures
      iii) Manually bias Secondary Air (SA) damper position control.
   b) Tests:

Test #	Description	Load Required	1/3 Dmpr. Position	2/3 Dmpr. Position	Inlet Dmpr. Position
1	Initial Conditions Test	550 MW	CLOSED	CLOSED	CLOSED
2	60-75% Load Test	a) 600 MW b) 700 MW	OPEN	CLOSED	OPEN
3	75-90 % Load Test	a) 725 MW b) 850 MW	CLOSED	OPEN	OPEN
4	90-Full Load Test	a) 875 MW b) 950 MW	OPEN	OPEN	OPEN

   c) Implement necessary mechanical and control corrections.

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3) Phase 3 – Performance testing: 1st Test Set (Typical Fuel Quality): April 7, 8, & 9;
2nd Test Set (Worst Case Fuel Quality) April 23 & 24.

Phase 3 tests are to be conducted on-line, at temperature, at different loads, with different fuel and mill configurations to verify NOx, CO, and unburned carbon control and adjust controls trim. The matrix listed below is recommended for both 1st and 2nd Test Sets.

a) Test Components
   i) Validate operational corrections – Repeat of Phase 2 test with controls in auto.
   ii) Measure and verify that NOx, CO, and unburned carbon levels are within guarantees at each load set.
   iii) At each load level, change mill configuration and verify operational and performance guarantees.
   iv) Test Set 1 to be completed with typical fuel blend.
   v) Test Set 2 to be completed with worst-case fuel blend in terms of slagging, fouling, and intrinsic sulfur, nitrogen, and non-combustibles content.
   vi) The duration of each test is dependent upon time required to stabilize unit operation following load, mill configuration, and OFA port positions changes.

b) Test Matrix:

IPSC OFA Performance Test Matrix										
Test #	Test Range	Generator Load Set	Test date & Duration	Operational Parameter Requirements:	Mills in Service		OFA Port Dmpr Pos.			Data to record
					Front	Back	1/3	2/3	Inlet	
1	60%	600 MW	4/7 – 2 hr	Per Contract	_FAE	GC_D	OPN	CLS	OPN	All
2	to		4/7 – 2 hr	requirements:	BFA_	GC_D				
3	75%	700 MW	4/7 – 2 hr	12.a - f, 12.k-n, 12.q.	BFA_	GCH_	OPN	CLS	OPN	All
4			4/7 – 2 hr	Fuel: as listed above.	_FAE	_CHD				
5	75% to	750 MW	4/8 – 2 hr	Per Contract	_FAE	_CHD	CLS	OPN	OPN	All
6	90%		4/8 – 2 hr	requirements:	BFA_	GCH_				
7		850 MW	4/8 – 2 hr	12.a - f, 12.k-n, 12.q.	BFA_	GCHD	CLS	OPN	OPN	All
8			4/8 – 2 hr	Fuel: as listed above.	_FAE	GCHD				
9	90%	875 MW	4/9 – 2 hr	Per Contract	_FAE	GCHD	OPN	OPN	OPN	All
10	to		4/9 – 2 hr	requirements:	BFAE	GCH_				
11	Full	950 MW	4/9 – 2 hr	12.a-h, 12.k-n, 12.q.	BFAE	GCH_	OPN	OPN	OPN	All
12	Load		4/9 – 2 hr	Fuel: as listed above.	BFAE	GCHD				

BR = burner data
B = boiler data
G= gas analysis grid data
FO = furnace observations
FA = fly ash sample
FL = fuel sample

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PRELIMINARY OPTIMIZATION TEST MATRIX

INTERMOUNTAIN POWER UNIT 2 (100210)

Test #	Main Steam Flow (10^3 lb/hr)	Boiler Load (% MCR)	Approx. Generator Load (MWg)	Excess Air (%)	Target Total OFA Flow (10^3 lb/hr)	Approx. Burner Zone Stoich., SR_B	Maximum Allowable OFA Flow for SR_B = 0.95 (10^3 lb/hr)	OFA Damper(s) Open	Mill Out of Service	Data [1]
1	6,285	95	900	18	1,100	1.0	1,400	1/3 & 2/3	G	All
2				16	980		1,280			BR, B, G, FO, FA
3				13.5	825		1,125			
4	5,940	90	850	16	925		1,190			
5	4,950	75	710	18	550	1.06	1,090	2/3		
6	4,055	61	575	20	220	1.15	970	1/3		
7	6,750	102	950	16	1,040	1.0	1,360	1/3 & 2/3		All
8	6,285	95	900		optimum	optimum	1,280			BR, B, G, FO, FA
9	4,055	61	575	20			970	1/3		All
10	6,750	102	950	16			1,360	1/3 & 2/3	E	
11	6,285	95	900	18			1,400			BR, B, G, FO, FA
12				16			1,280			
13				13.5			1,125			
14	5,940	90	850	16			1,190			
15	4,950	75	710	18			1,090	2/3		
16	4,055	61	575	20			970	1/3		All

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Over Fire Air Summary from 6/27/03 & 6/28/03

The following repairs and observations were made on the OFA system on 6/27 & 6/28:

The wear sleeves/journals for each of the inboard bearings on the through-all shafts for the OFA damper linkages were installed. Each damper set was cycled full stroke to check for interference problems with the new sleeves. No problems related to the sleeves were found. The first set installed was checked manually before continuing to install the remaining sleeve sets. Then, all shafts were checked with powered operation.

During the powered checks, cracks were found on welds that secured the inside actuator arm to the through-wall shaft on the NW 2/3 damper set. The cracking was not easily detected but did allow slippage during attempted damper operation Rechecked that weld point on all damper sets and found similar cracks on the NW 1/3 dampers and the SE 2/3 dampers but without significant slippage.

The cracked welds were repaired and reinforced. As a safeguard, similar reinforcement was completed all of the remaining inside and most of the outside actuator arms on the through-wall shafts.

The reinforcements consisted of ensuring three radial stitch welds were on or placed on both sides of each of the above listed actuator arms. All dampers were then re-checked by cycling full stroke to ensure proper operation. No further problems with cracking or radial slippage of the linkage arms was detected.

Through the repair and testing described above, the following additional problems were observed with the operation of the OFA linkages:

- Almost all through-wall shafts displayed a minimum of ½" (and in some cases +1") of axial movement during actuation. There was also shaft movement indicating a significant bending moment on the through-wall shafts as well.
- All 1/3 damper sets had to be manually assisted to cycle through full stroke. The NW 1/3 damper set would only move from 0% (closed) to a maximum of 75% of full stroke with manual assistance. This linkage, including each link point and linkage member, was carefully inspected and checked for interference problems or other obstructions preventing full stroke. No silver bullet was found. It would appear to be a combination of binding and resistance over the linkage as a whole that was preventing further actuation.
- During actuation of the various damper sets, further deterioration of the pillow-block bearing journals was observed.
- A popping was detected at the initial opening and just before reaching the full closed position on the SE inlet (feeder) damper set.

410 Stainless rod was used on the bearing sleeve welds. 309 Stainless was used on the actuator arm repairs.

IGS Uprate Project - Steam Generation and NOx Mitigation for 950 MW Operation
It has been proposed that the installation of pendant extensions with required SootBlowers (SB) and an Over Fire Air (OFA) system are required to support operation at 950 Megawatts. The installation of the following instrumentation and control capabilities and other considerations will be required for the successful implementation of these modifications:

NOx Mitigation

To safely implement staged combustion and OFA for the control and reduction of NOx emissions the following instrumentation and controls capabilities will be required[1]:

1 **Excess Air Measurement**
Accurate measurement and control of excess air is required to ensure complete and uniform combustion while implementing NOx control methods[2]. Capability requirements are as follows:

1.1 Installation of a CO Monitoring system.
1.2 CO system must accurately profile CO at the designated location in the gas path.
1.3 CO system must be capable of implementation in or integration with existing and future unit control systems at IGS to coordinate adjustments of the fuel to air stoichiometry to achieve staged but complete combustion.

2 **Combustion Air Distribution Measurement and Control**
Accurate measurement and control of secondary and over fire air distribution is required. Capability requirements for this are as follows:

2.1 Installation of a minimum of six (6) OFA ports per burner wall.[3]
2.2 Implementation of instrumentation to measure air flow at each OFA port.
2.3 Implementation of air flow control capability for each OFA port.
2.4 Implementation of accurate air flow measurement instrumentation to each burner[4], or at minimum the capability for accurate air flow measurement to each secondary air windbox with the pressure measurement capability within the windbox to monitor air distribution to each burner[5].

3 **Fuel Flow Measurement and Control**
Accurate determination of stoichiometry on a per burner basis will be required to effectively control both thermal and fuel NOx.[6] Variations in fuel distribution between burners and the latency between feeder measurement and actual delivery to the boiler effect the need for accurate measurement of coal flows and delivery per burner.[7] This capability shall include:

3.1 Fuel mass measurement capability
3.2 Fuel/air velocity measurement capability

4 **Accurate measurement of temperature and flame profiles in the primary combustion zone.**
Accurate determination of the stoichiometric profile of the primary combustion zone will be required for staged combustion control. Based on this information, adjustments to fuel/air biases can be made at either each burner or each burner level to ensure minimal NOx creation and ensure proper application of OFA for uniform and complete combustion. This capability shall include:

4.1 Flame temperature scanning for mapping of burner flame profile.
4.2 Real-time mapping of the primary combustion zone temperature and CO profiles.

5 Improved methods of monitoring and preparing fuel.
The following actions should be undertaken to improve fuel handling accuracy.
5.1 Coal mine classification and preparation of fuel size to required specification.[8]
5.2 Sizing QA of as delivered samples of fuel.
5.3 Investigation of coal feeder improvements.
5.4 Continuation of efforts to improve pulverizer performance through comprehensive predictive maintenance and investigation and application of viable rotating throat technology.

6 Other OFA Duct Instrumentation
Presuming the requirement of a 4:1 duct pressure increase for the OFA system, installation of control dampers at the split or "Y" is likely. The following concerns will need to be addressed.
6.1 Where will the OFA be extracted from the Secondary Air?
6.2 Duct pressure instrumentation will be required for upstream and downstream will be required.
6.3 OFA ports will require control dampers
6.4 OFA port and SA/OFA "Y" Damper position instrumentation and controls with tie-back to CCS will be required.
6.5 OFA temperature instrumentation will be required.
6.6 Fan performance and increase FD fan load will require monitoring.
6.7 Will OFA booster fans be required?

Steam Generation

1 Pendant Extension
No additional monitoring capability required.

2 Sootblowers
2.1 Steam flow and pressure measurement and controls.
2.2 Integration capability with existing SB controls systems and integration with future the future unit Digital Control System (DCS).

References:

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3. McDonald, D.K. and Madden, D.A.; "B&W's Advanced Coal Fired Low Emission Boiler System Commercial Generating Unit and Proof-of-Concept Demonstration", p.3, ASME International Joint Power

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